Tailor-made DEA models: an analysis of European farming without price aggregation

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APPC 2014, Brisbane

Application

- FADN database
- 100 – 3,000 farms in a region
- 20-30 different outputs (crops, livestock, income)
- Many outputs are actually produced by a small number of farms

Existing approaches

- Removal of outliers and clustering
  - does not increase the number of comparators
- Use only of common crops
  - penalises farms with diverse output profiles (by ignoring outputs)
- Value aggregation using output prices
  - measures allocative and not technical efficiency
  - prices are policy-distorted
  - forgoes multidimensional information, e.g. about the shadow prices and rates of substitution

Inputs and outputs

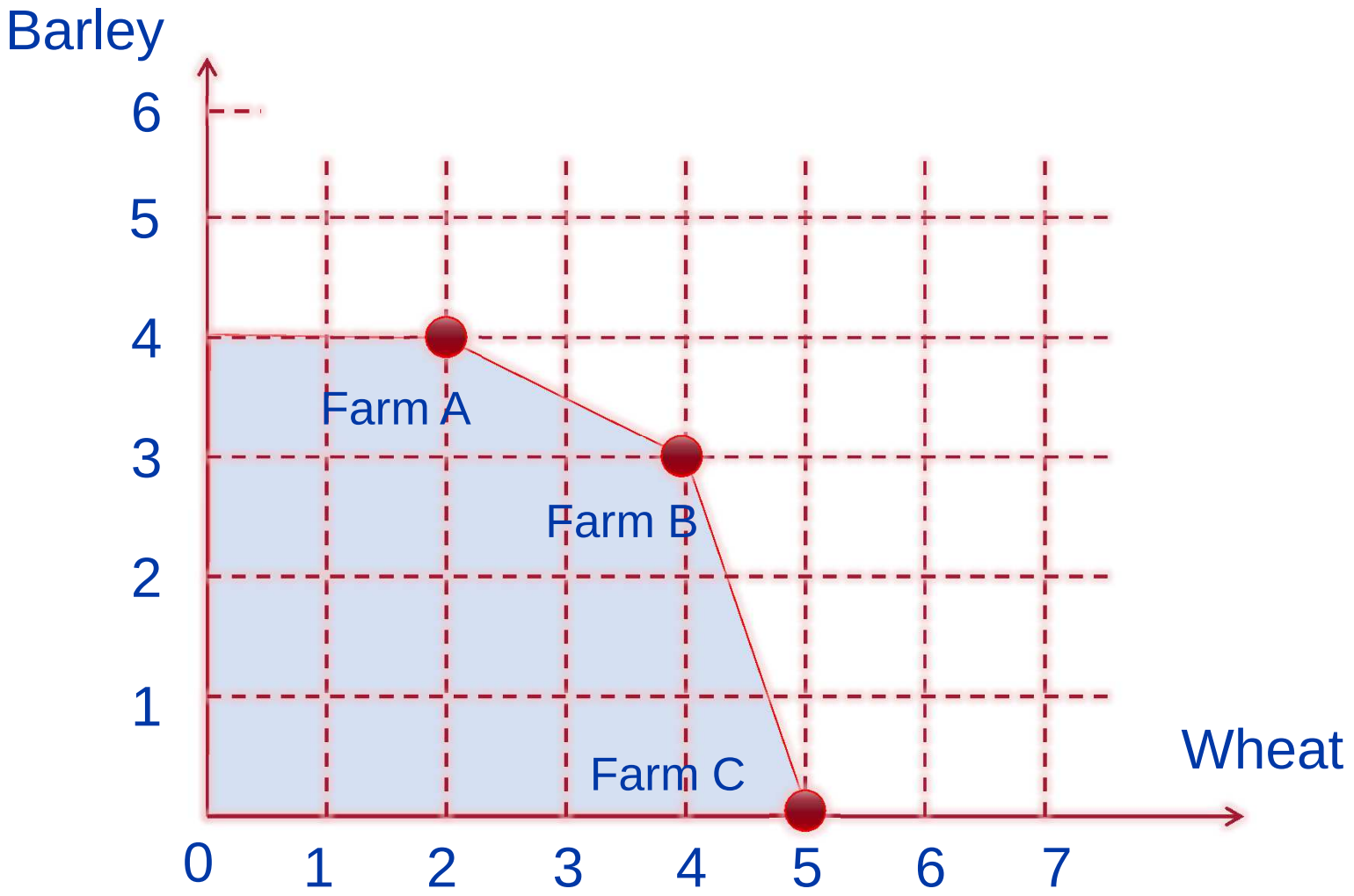
Inputs:

Land, capital, costs, labour

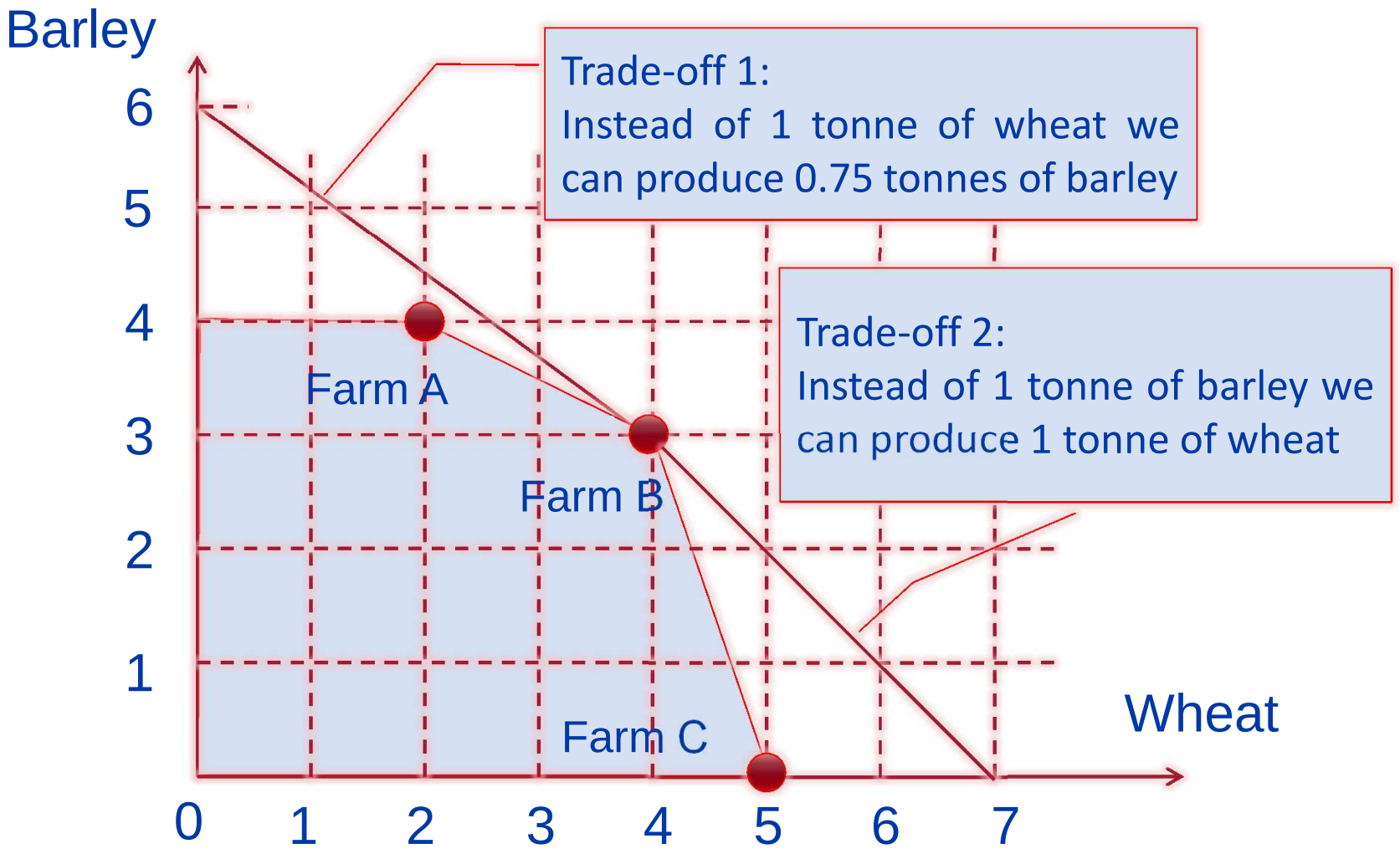
Outputs:

Wheat, barley, oats, rye, potatoes, sugar beet, other crops (price aggregated), livestock, farm net income

DEA model



Production trade-offs: a better-informed model



Production trade-offs: crops vs wheat

Trade-offs are expert estimates (assumptions).

Producing one unit of Wheat is equal (taking all resources into account) to producing between 0.4 and 0.8 units of Rye.

	Lower bound	Upper bound
Barley	0.75	1
Oats	0.25	0.5
Rye	0.4	0.8
Potatoes	4	8
Sugar beet	10	20
Other crops	Not used	Not used
Livestock	Not used	Not used
Farm net income	Not used	Not used

Models

The easiest way to incorporate trade-offs in DEA models is to restate them as weight restrictions and incorporate in the dual. E.g., for wheat and barley:

$$weight\_barley \geq weight\_wheat \geq 0.75\ weight\_barley$$

$$\theta_1^* = \max \quad u^T Y_0$$

$$\text{s.t.} \quad v^T X_0 = 1$$

$$u^T \bar{Y} - v^T \bar{X} \leq 0$$

$$u^T Q_t - v^T P_t \leq 0, \quad t = 1, \ldots, K$$

$$u, v \geq 0$$

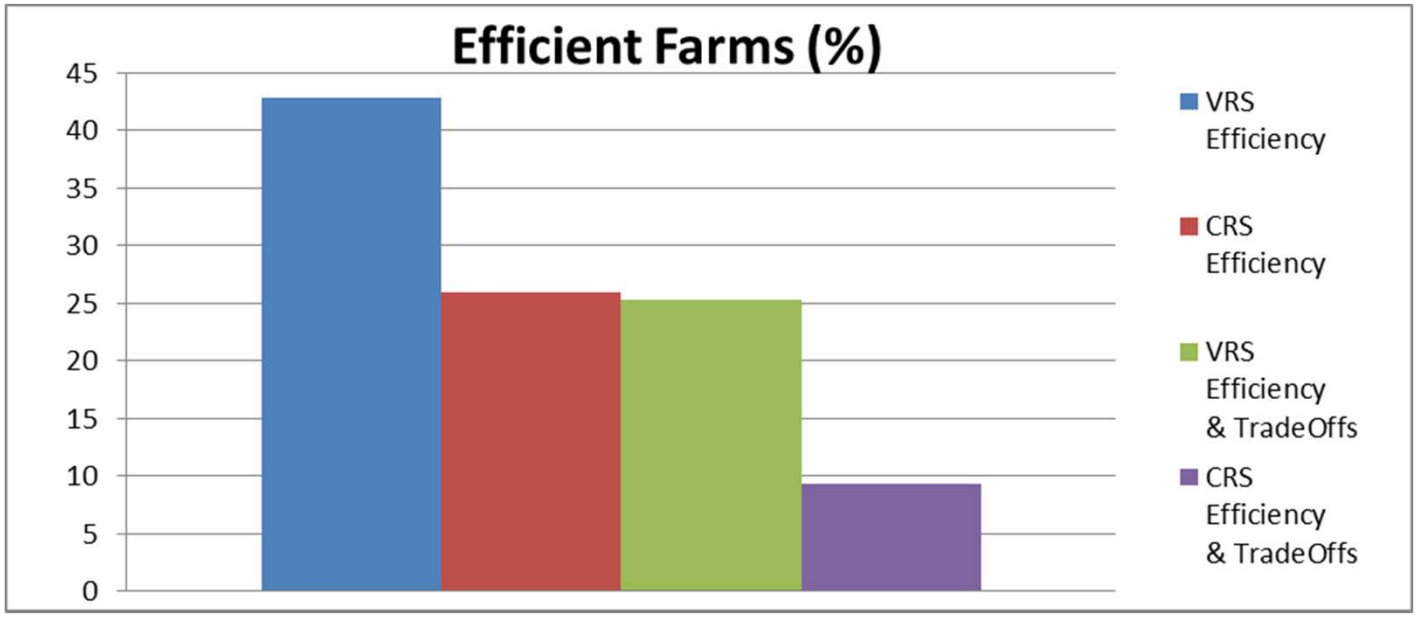
$$\theta_1^* = \min \quad \theta_1$$

$$\text{s.t.} \quad \bar{Y}\lambda + \sum_{t=1}^{K} \pi_t Q_t \geq Y_0$$

$$\bar{X}\lambda + \sum_{t=1}^{K} \pi_t P_t \leq \theta_1 X_0$$

$$\lambda, \pi \geq 0, \ \theta_1 \ \text{sign free}$$

Typical results



- FADN region 116, Germany – 300 farms

Elasticity measures and RTS

Long-run policy scenario

If we increase all inputs (land, assets, cost, labour) by 1%, how will the farm outputs respond?

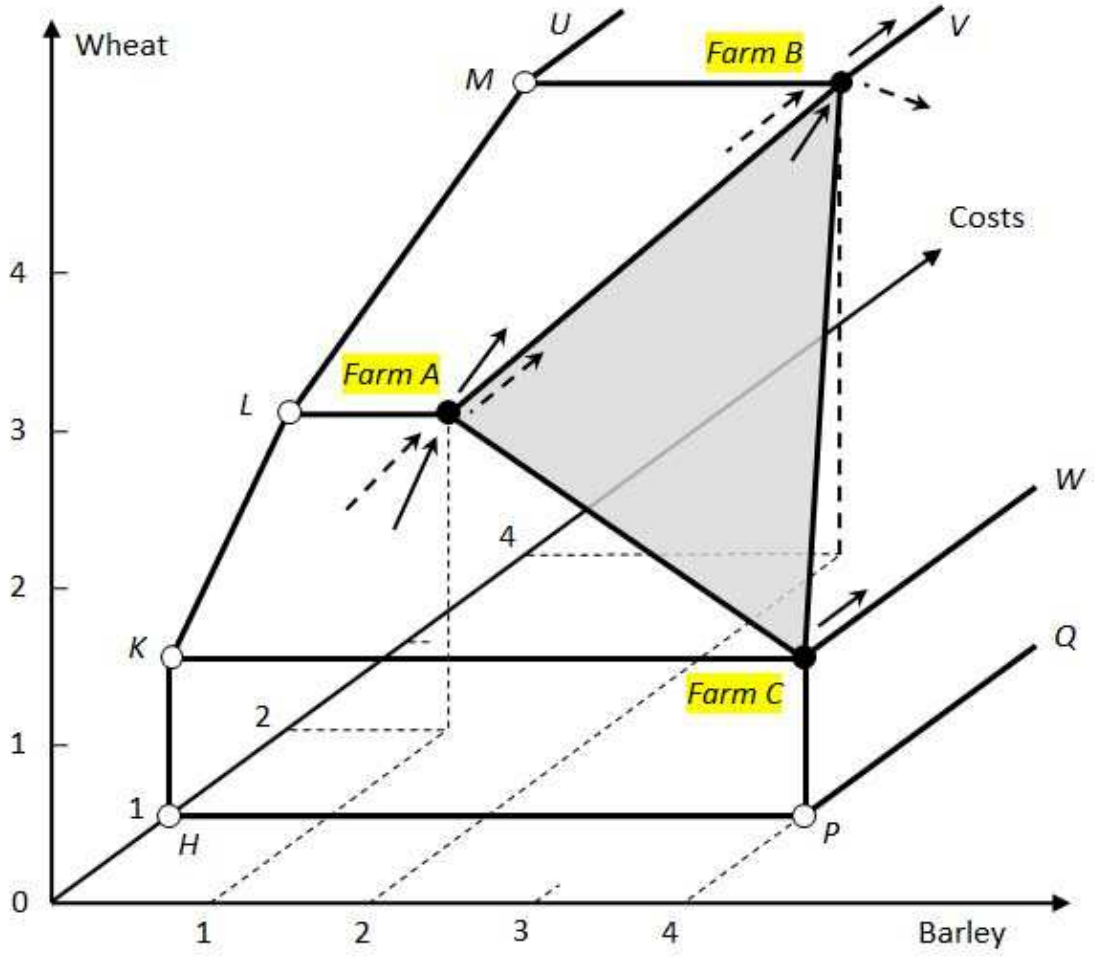
Short-run policy scenario

If we increase only cost and labour by 1%, how will the farm outputs respond?

Family net income

If we increase the size of the farm by 1% (or only cost and labour by 1%) how will the farm net income respond?

Elasticity of response: Wheat Vs Costs



Results

- There are different RTS types for the short and long-run policy scenarios in different EU regions.

  For example, in some EU regions (e.g. Austria, Ireland) farms predominantly exhibit IRS in the long-run scenario and DRS in the short run. (Over-farmed?)

- The elasticity of farm net income with respect to farm size (vector of farm inputs) is predominantly > 1. This implies IRS.

Relevant literature

Production trade-offs

- Podinovski, V.V. (2004) Production trade-offs and weight restrictions in data envelopment analysis. *Journal of the Operational Research Society*, **55**, 1311 – 1322.

Calculation of elasticity measures for different scenarios

- Podinovski, V.V., Førsund, F.R. (2010) Differential characteristics of efficient frontiers in data envelopment analysis. *Operations Research*, **58**, 1743 – 1754.

Conclusion

- Trade-offs are a good alternative to value aggregation.
- The use of trade-offs keeps the model full-dimensional, disaggregated.
- Models with production trade-offs differentiate significantly better than the standard DEA models.